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Propagation of Shock Waves in Real Gas Atmosphere

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A review on shock waves - Shock wave is a type of propagating disturbance, like an ordinary wave, it carries energy and can propagates through a medium (solid, liquid or gas) or in some cases in absence of the material medium, through a field as the electromagnetic field. Across a shock wave, there is always an extremely rapid rise in pressure, temperature and density of the flow. A shock wave travels through most media at a speed higher than ordinary wave. When shock wave passes through matter the total energy is preserved but the energy which can be extracted as work decreases and entropy increases.

Shock wave has applications in many field of interest as military operations, material processing, modern physics, engineering and medical science has been done successfully. Novel applications of shock waves in medical and biological science are remarkable. Shock wave therapy has been considered a mainstay of therapy and a widely used modality for treating many human diseases. Extracorporeal shock wave lithotripsy application is of great importance in vicinity of hematology of medical field and opens new doors for the novel application of shock waves in physiology of blood.

The problem of shock wave propagation has received considerable attention of researchers in recent years as a consequence of increasing speeds of bodies through the atmosphere. The propagation of spherical shock waves in stars has been investigated by Whitham (1953). Sakurai (1956) has studied the spherical shock waves through self-gravitating polytropic gas sphere such as stars, caused by an instantaneous central explosion of finite energy. Following the method of similarity, Kopal (1954) and Sedov (1959) studied the problem of shock propagation with constant strength in a special density distribution in the equilibrium states. The case of variable shock strength is discussed by Lidov (1955), Rogers (1956), Pai (1958), Bhatanagar and Lal (1965), Chaturani (1968), Kumar et al. (1981), have investigated the propagation of shock waves through a self gravitating gas. Their results are valid for strong shocks only.

An approximate method for solving problem in shock dynamics is developed by Chester (1954), Chisnell (1955) and Whitham (1958). This method (CCW) has been widely used by many authors, including Kumar et al. (1981), Kumar and Saxena (1984) and many others. CCW method, which is extremely simple and gives very good results in certain situations such as described by the so-called self-similar or auto model solutions of second kind (Zeldovich and Raizer-1967), does not give reasonable results for many problems in one hand. On the other hand in CCW method, a shock is not affected by the disturbances in the flow behind the shock i.e. CCW method describes freely propagating shock.

Yousal (1982, 1985) and Yadav (1992) have mentioned the significance of disturbances behind the flow on the motion of shock waves. The effect of overtaking disturbances on the motion of freely propagating shock has been studied by Yadav and Tripathi (1995), Yadav and Gupta (1995), Yadav et al., (2000) without including the concept of permissible shock fronts. The effect of overtaking disturbances on the motion of plane cylindrical

hydro magnetic shock in a self-gravitating gas at permissible shock front locations has been investigated by Kumar and Singh (1998, 1999).

Rathore (2002) and Yadav and Rathore (2003) have applied Yadav (1992) treatment to CCW method to study the effect of overtaking disturbances on the propagation of weak and strong cylindrical shock in a rotating gas. Mostly, in these investigations, the changes in the pressure and density behind shock have been studied. Yadav and Gangwar (2003) obtained the change in temperature of non uniform medium perturbed by freely propagating strong spherical diverging shocks.

Rossmanith (2005) has worked on a wave propagation method for hyperbolic systems on the sphere. They developed an explicit finite volume method for solving general hyperbolic system on the surface of sphere. Gretler and Regenfelder (2005) have worked on strong shock wave generated by a piston moving in a dust-laden gas under isothermal condition. A similar solution was found under isothermal condition of the flow field. Sakurai and Takayama (2005) studied the analytical solutions of flame field for weak much reflection over a plane surface. Danick (2006) have worked on shock wave based acoustic sniper localization. They investigated a successful iterative solution and presented in a computed example based on technically feasible measurement of the shock waves. Yoshida et al. (2006) have worked on role of volume on and attenuation value histogram of urinary stone on mono-contrast helical computed tomography as predictor of fragility by extracorporeal shock wave lithotripsy. Bazyn et al. (2006) have worked on pressure and temperature behind reflected shock waves. They presented experimental measurements on the combustion of nano-aluminum particles behind reflected shock wave in a shock tube. Hirsch and Plesek (2006) have worked on theoretical analysis of experimental results of shock wave loading of OFHC copper relating the observed internal structure to the deformation mechanism. Sayapin et al. (2006) studied experimentally, strong under water shock waves produced by electrical discharge. Fan et al. (2007) studied experimentally and numerically the interaction of a planner shock wave with a loose dusty bulk layer. Eliasson et al. (2007) investigated the influence of artificial disturbances on the behavior of strong converging shocks experimentally and numerically.

Yadav et al. (2009) studied adiabatic and isothermal propagation of spherical shock waves produced due to a nuclear explosion using energy hypothesis of Thomas. Chester (1954), Chisnell (1955), Whitham (1958) method, a very well known theory in shock dynamics is widely used by many researchers Kumar-1984, Gangwar-2002, Kishore and Kumar-2005, Yadav et al. 2006, 2007, 2008 etc.

Almost all authors have studied diverging or converging shock waves propagating in ideal gases or liquids/solids.

When the flow takes place at high temperature, the assumptions of ideal gases are no longer valid. Thus, motion of shock waves in real gases is close to actual situations, therefore, the propagation of shock waves in real gases is important to study.

Recently, Rana et al. (2015) studied the plane hydromagnetic shock wave through uniform and non-uniform media. Since earth is rotator, the entire medium liquids gases and solids are rotating. Therefore, the propagation of shock waves in rotating atmosphere is important to study.

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